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Conquistadors, cannibals and climate change A brief history of biochar

From Conquistadors to soil scientists, the evolution of terra preta into biochar is a bizarre and intriguing story. Progress has been slow and sporadic, yet research from the past decade hints at what could be a very exciting future. A new adventure is beginning.

Here be dragons

On 5 August 1495 Christopher Columbus received a rather peculiar letter from Royal Cosmographer Jaume Ferrer de Blanes. Ferrer was writing to inform Columbus of his discoveries in the New World, and in particular the apparent correlation between 'great and valuable things' and 'hot regions inhabited by darker skinned peoples.' He continued, 'and therefore, in my judgement, until Your Lordship meets such peoples, You shall fail to find an abundance of such things.' Seduced by the prospect of treasure, on his next voyage across the Atlantic Columbus turned sharply towards the equator, discovering South America. The consequences of Ferrer's flawed logic would transform the face of the world, and the entire way of life for indigenous Amerindians.



Francisco de Orellana

Fifty years on, the Europeans (now approaching South America from the west coast) were just as hungry for silver, gold and cinnamon. Conquistador Gonzalo Pizarro's expedition into unexplored territory east of Quito, Ecuador, was an attempt to seek them out. As part of this venture Pizarro ordered Lieutenant Francisco de Orellana to depart with a brigade of fifty men, to establish where the Coca and Napo Rivers joined. They reached the site on 26 December 1541, but rather than turning back the brigade's lust for riches drove them to threaten mutiny if they did not continue. Orellana had no choice but to prepare the men for a new and thrillingly dangerous voyage: the adventure had begun.

During eight months of travelling in two boats that they themselves had built, the crew became the first Europeans to navigate the Rio Negro and, eventually, to reach the Amazon River. From the very beginning of their voyage they encountered large indigenous settlements.

The diarist reported, 'there could be seen some very large cities that glistened in white, and besides this a land as good, as fertile, and as normal in appearance as our Spain.' Though the knowledge that humans could sustain themselves in the region was in principal good news for our starving voyagers, it also meant danger. As a general rule, 'savages' do not take kindly to Spaniards pilfering their food supplies. The indigenous men, even when equipped with poisoned arrows, posed no significant threat to our adventurers.

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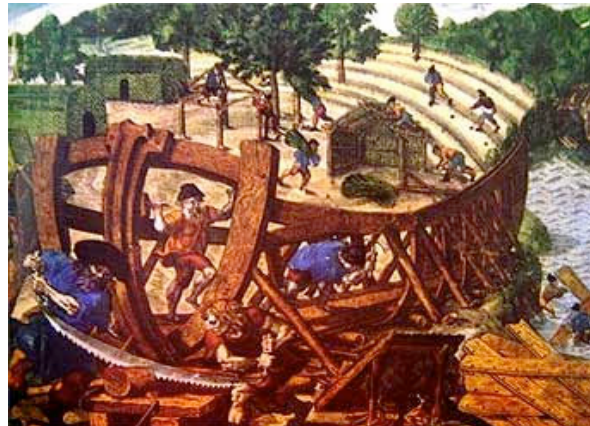
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The trouble, however, was that they were not always fighting men. Nothing could have prepared them for wrath of the Amazons. This female fighting force, with hair down to the floor and adorned with gold jewellery, ruled over large swathes of the region and regarded men as an unimportant annoyance required for reproduction only.

Upon joining the fray to protect their lands, the Amazons allegedly did 'as much fighting as ten Indian men' and could shoot arrows in such quick succession that within minutes 'our brigantines looked like porcupines.' When the Amazons were present, even the native men fought more aggressively as the women would instantly club to death anyone who tried to turn back.



Orellana's boat building

The Spaniards were forced to flee to the Province of the Black Men (Provincia de los Negros), where they endured heavy attacks from exceptionally tall, brightly dressed men who clipped their hair very short and stained themselves black. Although his crew wished to rest there to regain their strength, Orellana refused to stop until they had entered a less populated area - which proved to be a good call, as he learnt later that these Black Men 'ate human flesh'. Recounting his adventure to the Spanish Court, Orellana described the natives' advanced agricultural system, high population density and mixture of walled villages and isolated farms.

Focusing on the wealth of the Amerindians and eager to establish the origin of the precious metals worn by higher-ranking settlers, the Court granted Orellana funding for a second expedition along a different route. It was, however, an utter failure. Men and ships were lost on the passage and Orellana himself drowned when his boat capsized near the mouth of the Amazon. There were no subsequent voyages down the Amazon River until 1637, when Captain Pedro de Teixeira saw no trace of what Orellana had reported. He found no significant villages, let alone entire civilizations. Either Orellana was a liar, or millions of people and an entire way of life had been erased in less than a century. The astonishing world of the Amazonians was relegated to myth.

Unravelling the mystery

Years passed and nothing happened. The Amazon River basin was disregarded as a site of little wealth or interest. And then, something mundane but brilliant occurred. In 1870, James Orton, a little-known American geologist and explorer, noticed that alongside the typically grey, acidic soils of the basin there existed large patches of 'black and very fertile' soil. Though most would deem this remark insignificant, it is what soil scientist's dream of.

Researchers flocked to investigate the mysterious dark earth, or 'terra preta' as it is known locally.

In 1879, naturalist Herbert H. Smith's concluded that 'the bluff-land owes its richness to the refuge of a thousand kitchens for maybe a thousand years'. This finding, reinforced by geologist William Katzer's early twentieth century analysis of the soil composition - a blend of mineral residuum, charred plant materials and decomposed organics - started turning heads. Was this earth modified by human settlers? Had Orellana been telling the truth?

For many, this was a ridiculous idea. Betty J. Meggers, the renowned Smithsonian archaeologist, repeatedly argued that despite the river basin's rich flora, the Amazon's weak soils could not possibly retain the necessary nutrients for the agricultural requirements of a complex society. She asserted that any village containing more than 1000 inhabitants would have collapsed.

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However, similarly thin, acidic soil can be found in the savannah grasslands of Bolivia's Mojos Plains (Llanos de Mojos). Though few people live there as crops are so difficult to grow, William Denevan noted in the 1960s that the landscape was crossed with unnaturally straight lines: evidence of pre-historic large-scale cultivation. Additionally, when working with some indigenous Amerindian farmers who still inhabit the Plains, Clark Erickson and William Balée discovered linguistic clues to the lost civilization: 'They have words for domestic plants from 2000 years ago', says Balée.

The objections raised by Meggers have largely been discounted. Archaeological surveys have confirmed the correlation between the situation of the terra preta sites and the civilizations Orellana described back in the 16th Century. Furthermore, the presence of pottery shreds and food and animal waste in the soils demonstrates that they are anthropogenic in nature. Through careful cultivation over many centuries, the people of the Amazon were able to compensate for the limitations of their natural environment, creating a sustainable agricultural system capable of supporting possibly millions of inhabitants.



Normal soil

'Terra preta'

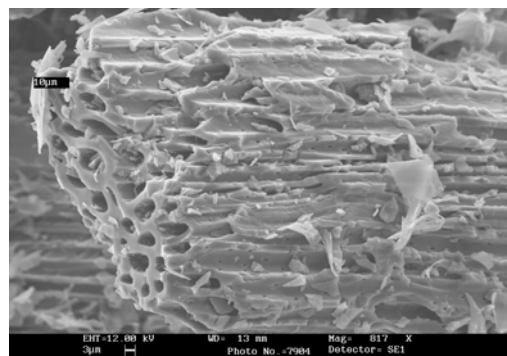
Based on linguistic and ceramic evidence, Donald Lathrap hypothesized in the 1960s that the confluence of the Amazon, Negro and Madeira River formed the centre of a vast and advanced civilization spanning from Brazil to the Caribbean. Its rapid decline has been predominately explained by the Old World diseases brought over by the Spanish, to which the Amerindians had no immunity.

A closer look at soil science

The rediscovery of this lost civilization is fascinating. Perhaps more surprisingly, so is terra preta itself: even chemical fertilizers cannot maintain crop yields into a third consecutive growing season, yet these dark earths have retained their fertility for centuries. A crop planted on terra preta can produce a yield up to four times greater than one planted on soil from similar parent material.

Furthermore, as first reported by Wim Sombroek in 1966, the earth seems to increase in biomass. Local farmers who mine the soil commercially claim that, as long as a patch of 20 square centimetres is left undisturbed, it can double in size within about 20 years. It is suspected that this phenomenon is caused by a combination of bacterial and fungal activity, though as yet no firm conclusion has been reached. So what is the secret behind the soil's unusually high fertility?

The key ingredient, it appears, is carbon. Terra preta soils contain up to 9 per cent carbon, compared with 0.5 per cent in surrounding soils. This is the cause of the earth's dark black colouring. The charcoal-like materials found in terra preta are most likely to originate from fireplaces used for cooking and firing clay pots: the patches with the highest carbon concentrations appear to be those situated by village refuse sites.



Biochar under the microscope

Charcoal was likely to have been produced by charring organic waste in primitive ovens with a low-oxygen supply, for use as fuel. High-carbon char changes the chemical behaviour of the soil, facilitating its retention of nutrients such as calcium, thereby improving growing conditions. It is not yet clear whether carbon was added accidentally or deliberately by the Amazonians.

Terra preta plots range in from just a few m² to 900 acres, with the oldest site dating from 8000 BC. Because living organisms cannot process the thermally-transformed structures in the char, carbon has been stashed away in the earth, sometimes for thousands of years. Aside from increased crop productivity, it therefore seems that terra preta offers a second significant benefit: as described in Sombroek's 1992 publication, 'Biomass and carbon storage in the Amazonian ecosystems', it has the potential to sequester carbon.

Bruno Glaser of the University of Bayreuth has calculated that a hectare of metre-deep terra preta could hold up to 250 tonnes of carbon, compared with the maximum of 100 tonnes in unimproved soils from the same area. Researchers, prominent amongst them Johannes Lehmann of Cornell University, began to explore the possibility of enhancing soil fertility and storing carbon with newly-produced char. The materials they used have come to be referred to as 'biochar'.

A green revolution?

Biochar is formed by charring agricultural waste, for example rice husks, by pyrolysis (heating in a low-oxygen or air-free environment) rather than burning it. If dug into the soil, the captured carbon can remain there for centuries. The traditional 'slash and burn' method of clearing typically releases 97 per cent of the forest's carbon into the atmosphere. Persuading subsistence farmers to use 'slash and char' instead could reduce that figure to less than 50 per cent. Biochar-improved soils may also release less methane and nitrous oxide, both of which are more potent greenhouse gases than carbon dioxide. As for crop yields, field trials carried out by independent scientists and Pro-Natura International have shown promising results. For instance in 2008, in the most severely degraded sites included in the study, Kenyan maize fields improved with biochar produced double the yield of those improved with chemical fertilizers. As hundreds of studies worldwide are starting to confirm biochar's efficacy as a soil amendment, it is being understood as a powerful tool to produce enough food for our planet's expanding population.

Pro-Natura International has been producing and testing biochar initially in the Saint Louis region of Senegal, where it has a Pyro-6F, a self-sustaining pyrolysis machine, that is capable of transforming 500 kg of rice husks into 200 kg of biochar per hour (the rest becomes combustible gas, used to power the machine). Should farmers have access to such pyrolysis technology, the adoption of biochar techniques would be quicker and agricultural productivity improvements more pronounced.



Pyro-6F carboniser

Today, most biochar-related activity is linked to the International Biochar Initiative (IBI), a non-profit organisation open to interested scientists, to those formulating climate-change policy, and to NGO's and businesses interested in the application of biochar technologies. Founded in 2006 by a team including Johannes Lehmann, the IBI Chairman, and Stephen Joseph of the University of New South Wales, it serves as an information exchange for national initiatives, including those of the USA, China and India. Its main objectives involve encouraging biochar research, increasing awareness, and setting quality and sustainability standards.

As the scientific base matures, the IBI's attention is turning to the economics and the business structures that could promote the large-scale adoption of biochar technology in ways that are sustainable and financially viable.

This is no easy task, but it is worth attempting. As summarised by scientist James Lovelock, author of 'The Gaia Theory', *'There is an outside chance that one procedure could really turn back the clock on Global warming and that is burying carbon. All you have to do is get every farmer everywhere to make a profit by turning all his agricultural waste into char and burying it.'*



Rice without biochar in Northern Senegal

With biochar yield doubled

From Conquistadors to soil scientists, the evolution of terra preta into biochar is a bizarre and intriguing story. Progress has been slow and sporadic, yet research from the past decade hints at what could be a very exciting future. A new adventure is beginning. Orellana's men never did bring home the precious metals of the hot regions, but their discovery of the rich and fertile soil might just prove a greater gift: a means of slowing the course of global warming, and of better providing for the world population's nutritional needs. Besides, it would be a nice historical irony if the destroyed 'savage' civilisation ended up saving the advanced one that caused its downfall. ■

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